# Aeronautics Committee Report to the NASA Advisory Council

Ms. Marion Blakey (Chair)

April 28, 2010

# Areas of Interest Explored at Current Meeting

Unmanned Aircraft Systems (UAS) Research Planning

Verification & Validation (V&V) Research Planning

Aeronautics Test Program Overview and Strategy

# Unmanned Aircraft Systems (UAS) Research

The need to fly UAS in the National Airspace System (NAS) is of increasing urgency to perform missions of vital importance to national security and defense, emergency management, and science (DOD, DHS, FEMA, NASA, DOC, NOAA)

UAS are unable to routinely access the airspace system today due to lack of:

- Adequate and automated separation assurance and conflict avoidance
- Robust communication technologies
- Robust pilot-vehicle interfaces
- Standardized safety and certification

All current aviation regulations are built upon the condition of a pilot being on board vehicles.

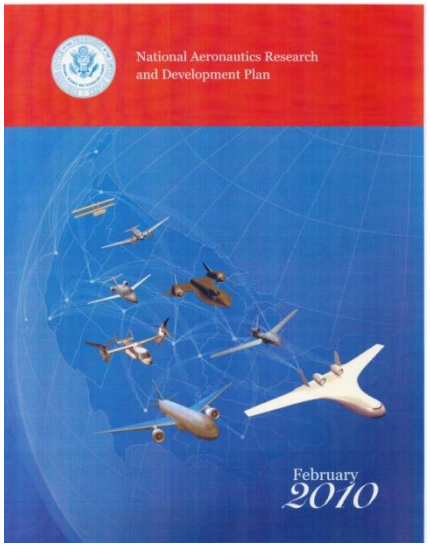
The NASA UAS initiative ($30M per year in the FY 2011 President's Budget) will enable the development of key technologies and procedures necessary to enable seamless operation and integration of UAS in the NAS. The UAS integration into the NAS is one of the key challenges for today's NAS and for the NextGen Air Traffic Control System.

# NASA's Research Focus

Focus on enabling seamless UAS operations and technologies that provide a bridge from today to full NextGen implementation

- Collaborate with the UAS ExCom (FAA, DOD, NASA, DHS), JPDO and industry standards organizations to define and conduct research
  - NASA will work with the FAA and DOD to support their focus on today's Public UAS access problems through UAS ExCom engagement
  - Complement DOD and FAA work to ensure that a coordinated portfolio of high priority UAS access R&D elements for NextGen are addressed
- Build upon our existing Research Transition Team process to actively engage implementers and stakeholders to transfer technology and accelerate implementation

*Proposed effort aligns with the National Aeronautics Research and Plan section "Mobility Through the Air is Vital to Economic Stability, Growth and Security as a Nation", dated February 2010.*



# Major Technical Barriers

- Separation assurance and conflict avoidance
  - —Automated separation assurance algorithms for seamless and safe operation of UAS in high density NextGen operating environment
  - —Allocation of roles and responsibilities between automation and humans in identifying conflicts and providing separation assurance
- Communications
  - —Allocation of spectrum
  - —Robust datalink and satellite communications
- UAS vehicle interface
  - —Definitions of roles and responsibilities between pilots and controllers, remote pilot control interface, autonomous flight operations
- Certification and Interoperability
  - —Research/Analytical based approach, built on the FAA regulatory framework, to provide data that supports development of UAS airworthiness standards and operational requirements to address the unique certification issues of UAS

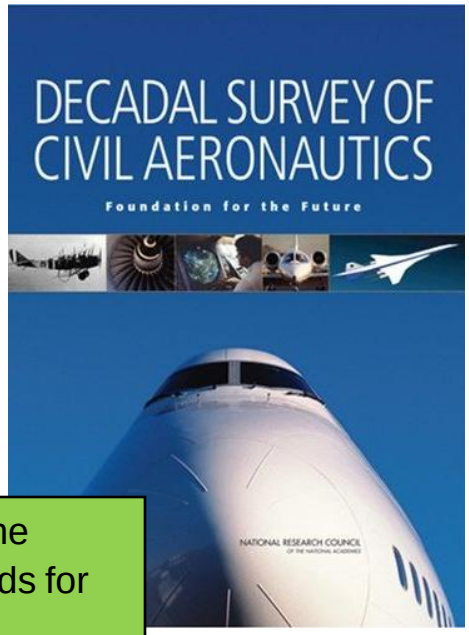
# Verification & Validation Research

- The V&V of Flight Critical Systems initiative ($20M per year in the FY 2011 President's Budget) will enable NASA to provide technical leadership for advancing V&V capabilities, which was identified as one of the major gaps for realizing the NextGen vision by the Joint Planning and Development Office (JPDO).
- Objectives of eventual research
  - Demonstrate advanced methods to answer relevant questions from aviation community
  - Reduce barriers to innovation associated with safety V&V
  - Develop V&V methods for safety throughout the entire life cycle
- Key themes in research needs
  - Make V & V Cost- and Time-Effective
  - Support the Entire Product Lifecycle
  - Consider Disturbances & Degradations
  - Humans and Software Are Central

# V&V: Broad Challenge

"Developers do not have effective ways to model and visualize software complexity, including the possible range of interactions, especially unexpected and anomalous behaviors that can occur among software and hardware components.

Developers also do not have time- or cost-effective ways to test, validate and certify that software-based systems will perform reliably, securely and safely as intended, particularly under attack or in partial failure."


Fundamental research is needed to create the foundations for practical certification standards for new technologies

- methods and models are needed for assessing the safety and reliability of complex, large-scale, human-interactive, nondeterministic software intensive systems

JPDO Identified Critical Gap in V&V Methods

# Cost (and time) Barrier

- With current methods, V&V can cost more than all other design and implementation costs combined -in some cases effectively prohibiting novel operations and technologies.

| System | Lines of Code |
|---|---|
| Mars Reconnaissance Orbiter | 545K |
| Orion Primary Flight Sys. | 1.2M |
| F-22 Raptor | 1.7M |
| Seawolf Submarine Combat System AN/BSY-2 | 3.6M |
| Boeing 777 | 4M |
| Boeing 787 | 6.5M |
| F-35 Joint Strike Fighter | 5.7M |
| Typical GM car in 2010 | 100M |

Size Comparisons of Embedded Software

*NASA Study*
Flight Software Complexity, 4/23/2009

Software example. Also need to consider human performance, concepts of operation and new technologies!

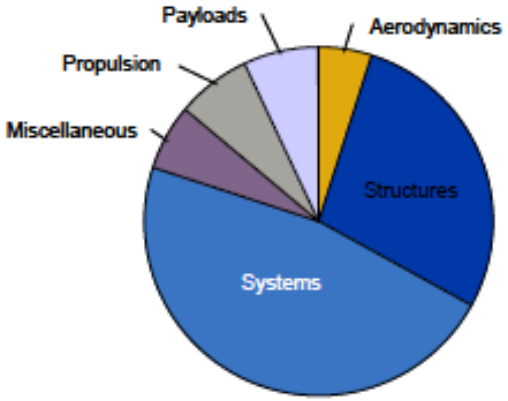
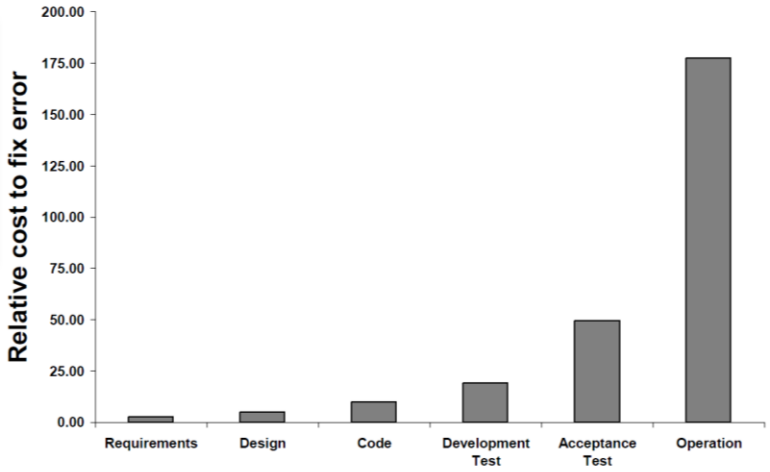



Fig. 1 - Typical Transport Aircraft Development Cost Distribution – Current Generation

Winter, D. (VP, Engineering & IT, Boeing PW)
Testimony to House Committee on Science and Technology, July 31, 2008

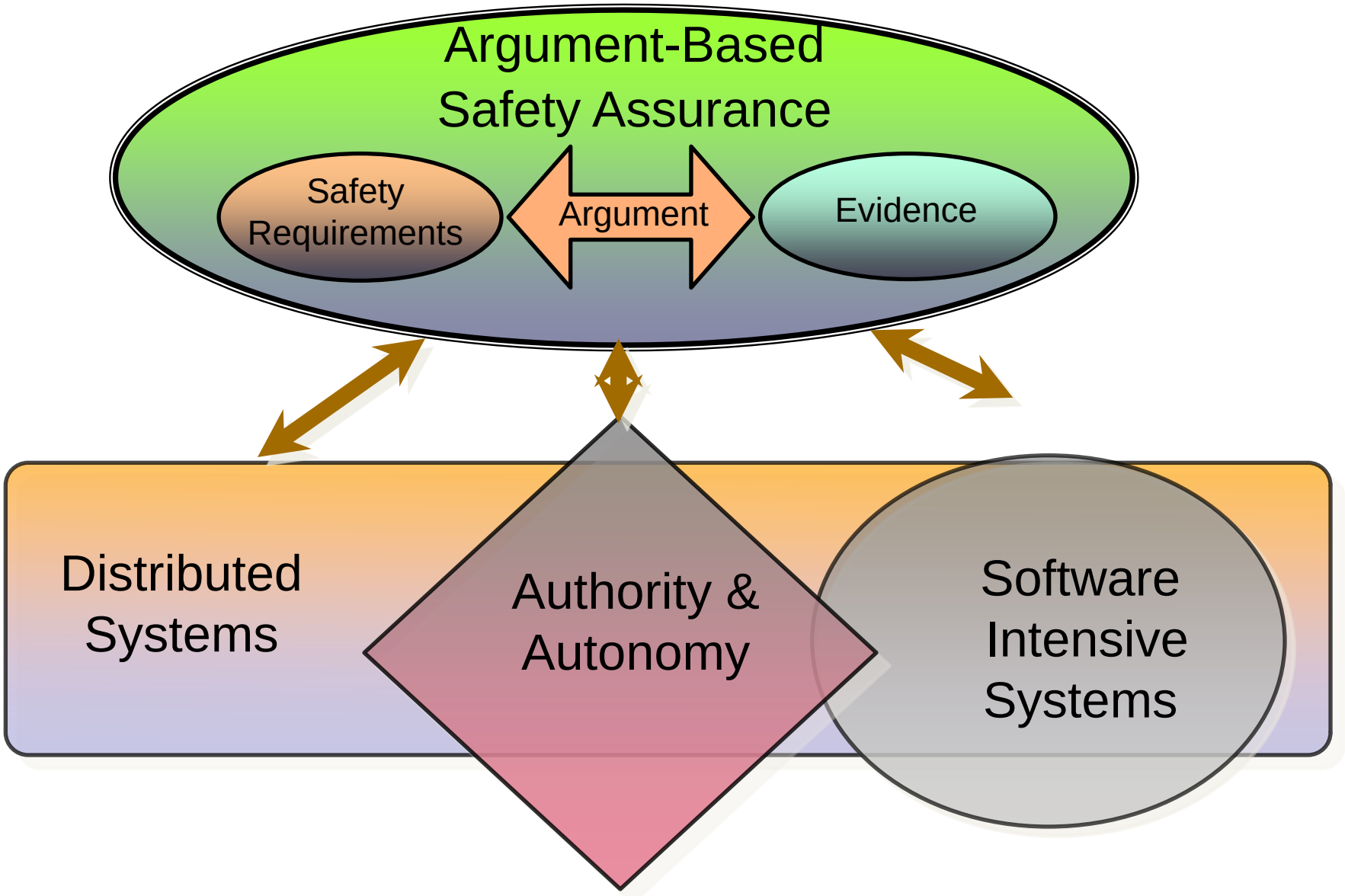



Boehm, B. 1981 *Software Engineering Economics*, as cited in DAA, 2008

More S/W

Late-on Testing

# Critical Research in Four Challenge Areas



# Committee Observations

1) The NAC Aeronautics Committee endorses ARMD taking on the important problem of UAS operations in the NAS.
2) The NAC Aeronautics Committee endorses ARMD taking on the important problem of systems Verification and Validation (V&V). V&V affects all modern aircraft and air transportation and space systems. This is an extremely challenging area which the Committee feels will require new and innovative approaches and may require expertise outside of NASA's current skill set. We urge NASA acquire current state of the art expertise in V&V and current practice in dealing with real-world problems in this area. We also suggest ARMD use this area as a challenge problem to stimulate ideas and solutions.

# Aeronautics Test Program Strategy

- **National stewardship**. ATP is committed to ensuring healthy and available aeronautics test capabilities not just for NASA but for the nation.
- **Availability, not necessarily ownership**. NASA does not have to own and operate all test facilities needed, but ATP will ensure it can access them through strategic partnerships.
- **Relevance.** Capabilities must evolve to meet future test requirements.
- **"The Big Stuff."** ATP will focus on national-class test capabilities, rather than the quantity or breadth of smaller laboratory facilities.
- **Value.** Reliable facilities and efficient processes will help customers get the most benefit from testing.
- **Public good.** NASA has a role in providing test capabilities that are not economically viable as independent business and thus not available elsewhere.
- **R&D and T&E.** A test facility can support both R&D as well as test and evaluation (T&E) activities.

# ATP Assets

**AMES RESEARCH CENTER**

- Unitary Plan Wind Tunnel

**GLENN RESEARCH CENTER**

- Icing Research Tunnel
- 10x10 Supersonic Unitary Wind Tunnel
- 8x6 Transonic Wind Tunnel
- 9x15 Low Speed Wind Tunnel
- Propulsion Systems Lab

**LANGLEY RESEARCH CENTER**

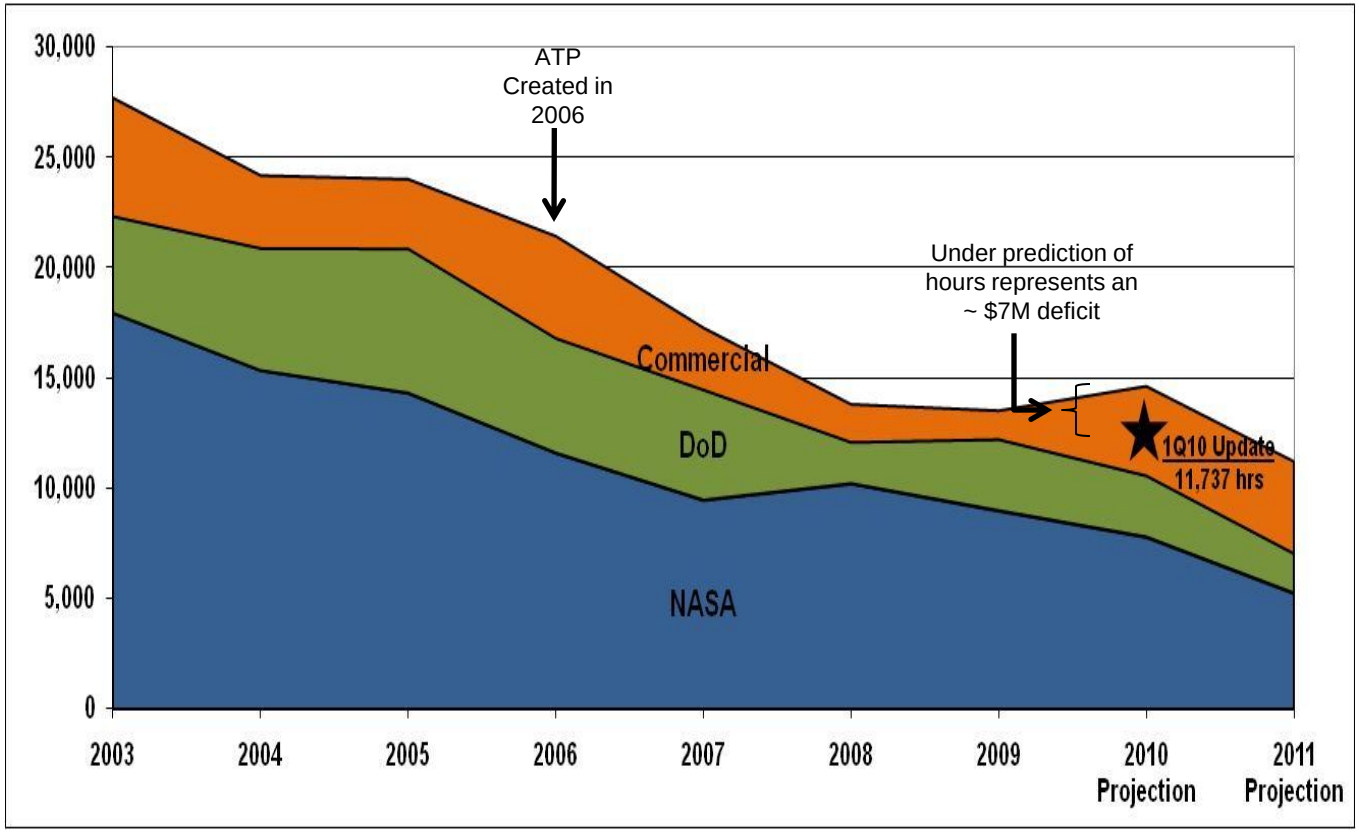
- National Transonic Facility
- 8-foot High Temperature Tunnel
- Langley Aerothermodynamics Lab
- 14x22 Subsonic Wind Tunnel
- Transonic Dynamics Tunnel
- 4-foot Supersonic Unitary Tunnel
- 20-foot Vertical Spin Tunnel

**DRYDEN FLIGHT RESEARCH CENTER**

- Western Area Test Range
- Support Aircraft
- Test Bed Aircraft
- Flight Loads Laboratory
- Research Aircraft Integration Facility

*Icing Research Tunnel*

# ATP Ground Utilization Trend by User (Hours)

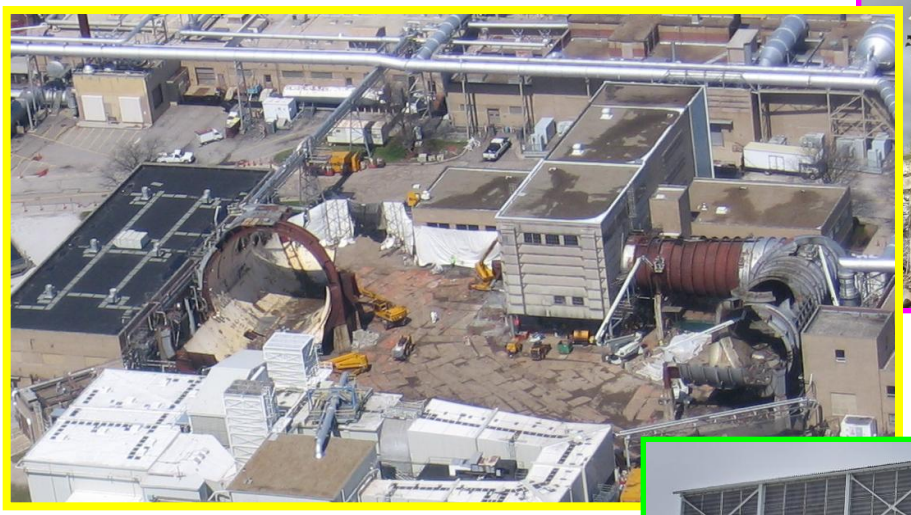



~ 11,000 hour decline in customer usage represents ~ $34M in customer revenue

# Landscape is Changing

ARC 14’ Transonic Tunnel


GRC Altitude Wind Tunnel



LaRC 7’x10’ High-Speed Tunnel

# Committee Recommendation

The Committee observes that the utilization data for the ATP facilities continues a downward trend. This trend left unabated is a "going out of business" trend. The cost gap is increasingly difficult to close. Some of these facilities will be essential for future national air and space priorities. CFD is not a sufficient replacement.

There have been numerous studies looking at this problem, including the recent strategic planning done by ATP.

1) It is urgent that an Agency-wide plan be developed to stabilize and where possible reverse the situation including supporting and improving the technical capabilities and operations of the most critical facilities and deaccessioning some facilities through sale or gifts.

# Committee Information

- Members:
  - Ms. Marion Blakey (Chair)
  - Dr. Ilan Kroo
  - Dr. Mark Lewis
  - Mr. Preston Henne
  - Dr. R. John Hansman
  - Mr. Mark Anderson
  - Dr. Harry McDonald
  - Mr. Paul Adams
  - Dr. Ray Colladay (ex-officio)
- Plans for next meeting: Face-to-face Committee Meeting at Glenn Research Center in late July.